

CLAIMS

1. An exposure apparatus that exposes a substrate by emitting exposure light onto the substrate through a projection optical system and a liquid, comprising:
a detection apparatus that detects whether the liquid is present on an object, which is disposed lower than a front end of the projection optical system.
2. An exposure apparatus according to Claim 1, wherein:
said detection apparatus has an emitting portion that emits detection light and a light receiving portion disposed at a predetermined position with respect to the detection light.
3. An exposure apparatus according to Claim 2, wherein:
said detection light is emitted from said emitting portion to a plurality of positions, and at least one of a size and a shape of the liquid is obtained based on a light receiving result of said light receiving portion.
4. An exposure apparatus according to Claim 2, wherein:
the detection is performed while relatively moving the detection light of said detection apparatus and said object.
5. An exposure apparatus according to Claim 4, wherein:
said object is movable with respect to said projection optical system.

6. An exposure apparatus according to Claim 5, wherein:

said object includes at least one of said substrate, a substrate stage that is movable and holds said substrate, and a predetermined member on the substrate stage.

7. An exposure apparatus according to Claim 2, comprising:

a bending portion that bends an optical path of the detection light of said detection apparatus.

8. An exposure apparatus according to Claim 2, wherein:

the detection light of said detection apparatus is emitted substantially parallel to a surface of said object.

9. An exposure apparatus according to Claim 8, wherein:

whether the liquid is present in an optical path of the detection light is determined based on a light receiving result of said light receiving portion.

10. An exposure apparatus according to Claim 8, wherein:

the detection light passes through an area away from the surface of said object by 5.5 mm or less than 5.5 mm.

11. An exposure apparatus according to Claim 2, wherein:

a position of the liquid on said object is obtained based on a light receiving result of said light receiving portion.

12. An exposure apparatus according to any one of Claim 2 through Claim 11, wherein:
said detection apparatus emits the detection light to an immersion area of the liquid formed between said projection optical system and said object.
13. An exposure apparatus according to any one of Claim 2 through Claim 7, wherein:
said detection apparatus emits the detection light to a surface of said object.
14. An exposure apparatus according to Claim 13, wherein:
said light receiving portion receives light from the surface of said object, and the liquid on the surface of said object is detected based on the light receiving result.
15. An exposure apparatus according to Claim 13, wherein:
the surface of said object irradiated by the detection light includes a recessed portion formed on said object.
16. An exposure apparatus according to Claim 15, wherein:
the recessed portion is provided to a substrate stage that is movable and holds said substrate, and a substrate holder that holds said substrate is disposed in the recessed portion.
17. An exposure apparatus according to Claim 16, wherein:
the emission of the detection light to said substrate holder is performed before loading the substrate on said substrate holder.

18. An exposure apparatus according to any one of Claim 2 through Claim 17, wherein:
the detection light is infrared light of a predetermined wavelength.
19. An exposure apparatus according to Claim 2, wherein:
the detection light includes a sheet light flux emitted so that an area of the liquid which is equal to or greater than a predetermined size is covered with the sheet light flux.
20. An exposure apparatus according to Claim 1, comprising:
a liquid supply mechanism that supplies the liquid; and
a liquid recovery mechanism that recovers the liquid;
wherein an operation of at least one of the liquid supply mechanism and the liquid recovery mechanism is controlled based on a detection result of said detection apparatus.
21. An exposure apparatus according to Claim 20, wherein:
the supply of the liquid by said liquid supply mechanism is stopped if it is determined that the detection result of said detection apparatus is abnormal.
22. An exposure apparatus according to Claim 1, wherein:
an exposure operation is controlled based on a detection result of said detection apparatus.
23. An exposure apparatus according to Claim 1, wherein:

a warning is issued if it is determined that a detection result of said detection apparatus is abnormal.

24. An exposure apparatus that exposes a substrate by emitting exposure light onto the substrate through a projection optical system and a liquid, comprising:

a detection apparatus having an emitting portion that emits detection light to an immersion area formed between the projection optical system and an object disposed on an image plane side of the projection optical system, and a light receiving portion that is disposed at a predetermined position with respect to the detection light, wherein the detection apparatus obtains at least one of a size and a shape of the immersion area based on a light receiving result of the light receiving portion.

25. An exposure apparatus according to Claim 24, wherein:

at least one of the size and the shape of said immersion area is obtained based on the light receiving result of the detection light emitted to a plurality of positions in said immersion area.

26. An exposure apparatus according to Claim 24, wherein:

a detection by said detection apparatus is performed in parallel with the exposure of said substrate.

27. An exposure apparatus according to Claim 24, wherein:

the detection light is emitted to the vicinity of an edge portion of said immersion area.

28. An exposure apparatus according to Claim 24, wherein:
the detection light is emitted to each of a plurality of positions in the vicinity of an edge portion of said immersion area.
29. An exposure apparatus according to Claim 28, wherein:
optical paths of a plurality of beams of the detection light emitted to the vicinity of said edge portion are set in accordance with a target shape of said immersion area.
30. An exposure apparatus according to Claim 28, wherein:
at least two of said plurality of beams of the detection light are emitted to the vicinity of edge portions on both sides of said immersion area, respectively.
31. An exposure apparatus according to Claim 24, comprising:
a liquid supply mechanism that supplies the liquid; and
a liquid recovery mechanism that recovers the liquid;
wherein an operation of at least one of the liquid supply mechanism and the liquid recovery mechanism is controlled based on a detection result of said detection apparatus.
32. An exposure apparatus according to Claim 31, wherein:
the supply of the liquid by said liquid supply mechanism is stopped if it is determined that the detection result of said detection apparatus is abnormal.
33. An exposure apparatus according to Claim 31, wherein:

the supply of the liquid by said liquid supply mechanism is stopped if said immersion area of the liquid formed between the projection optical system and the substrate has become, or larger than a predetermined size.

34. An exposure apparatus according to Claim 24, wherein:

the detection light is infrared light of a predetermined wavelength.

35. An exposure apparatus according to Claim 24, wherein:

the detection light includes a sheet light flux emitted so that an area of the liquid which is equal to or greater than a predetermined size is covered with the sheet light flux.

36. An exposure apparatus that exposes a substrate by emitting exposure light onto the substrate through a projection optical system and a liquid, comprising:

a shape detection apparatus that obtains a shape of the liquid on an object which is movable on an image plane side of the projection optical system.

37. An exposure apparatus according to Claim 36, wherein:

said detection apparatus having an emitting portion that emits a plurality of detection light arrayed in a vertical direction with respect to a surface of said object, and a light receiving portion that is disposed at a predetermined position with respect to the detection light, wherein the detection apparatus obtains the shape of the liquid based on a light receiving result of the light receiving portion.

38. An exposure apparatus according to Claim 36, wherein:

an affinity of the liquid for said object is obtained based on said obtained shape of the liquid.

39. An exposure apparatus according to Claim 36, wherein:

a contact angle of the liquid with respect to said object is obtained based on said obtained shape of the liquid.

40. An exposure apparatus according to Claim 39, wherein:

said detection apparatus detects a height of the liquid on said object, and obtains the contact angle of the liquid with respect to said object based on a result of the detection.

41. An exposure apparatus according to Claim 36, wherein:

said object includes at least one of said substrate, a substrate stage that holds said substrate, and a predetermined member of the substrate stage.

42. An exposure apparatus that exposes a substrate by emitting exposure light onto the substrate through a projection optical system and a liquid, comprising:

a detection apparatus that detects a contact angle of the liquid, on an upper surface of a substrate stage that holds the substrate, with respect to the upper surface of the substrate stage.

43. An exposure apparatus according to Claim 42, wherein:

the contact angle of the liquid with respect to the upper surface of said substrate stage is obtained periodically.

44. An exposure apparatus according to Claim 42, wherein:

the upper surface of said substrate stage includes a surface of a predetermined member which is replaceably disposed on said substrate stage, and the predetermined member is replaced based on said detected contact angle.

45. An exposure apparatus according to Claim 42, wherein:

the upper surface of said substrate stage includes a surface of the substrate held by said substrate stage.

46. An exposure apparatus according to Claim 42, comprising:

a liquid supply mechanism that supplies the liquid; and

a liquid recovery mechanism that recovers the liquid;

wherein an operation of at least one of the liquid supply mechanism and the liquid recovery mechanism is controlled based on said detected contact angle.

47. An exposure apparatus according to Claim 42, wherein:

said detection apparatus detects the contact angle by emitting infrared light of a predetermined wavelength to the liquid on said substrate stage.

48. A device manufacturing method using an exposure apparatus according to any one of Claim 1, Claim 24, Claim 36, and Claim 42.